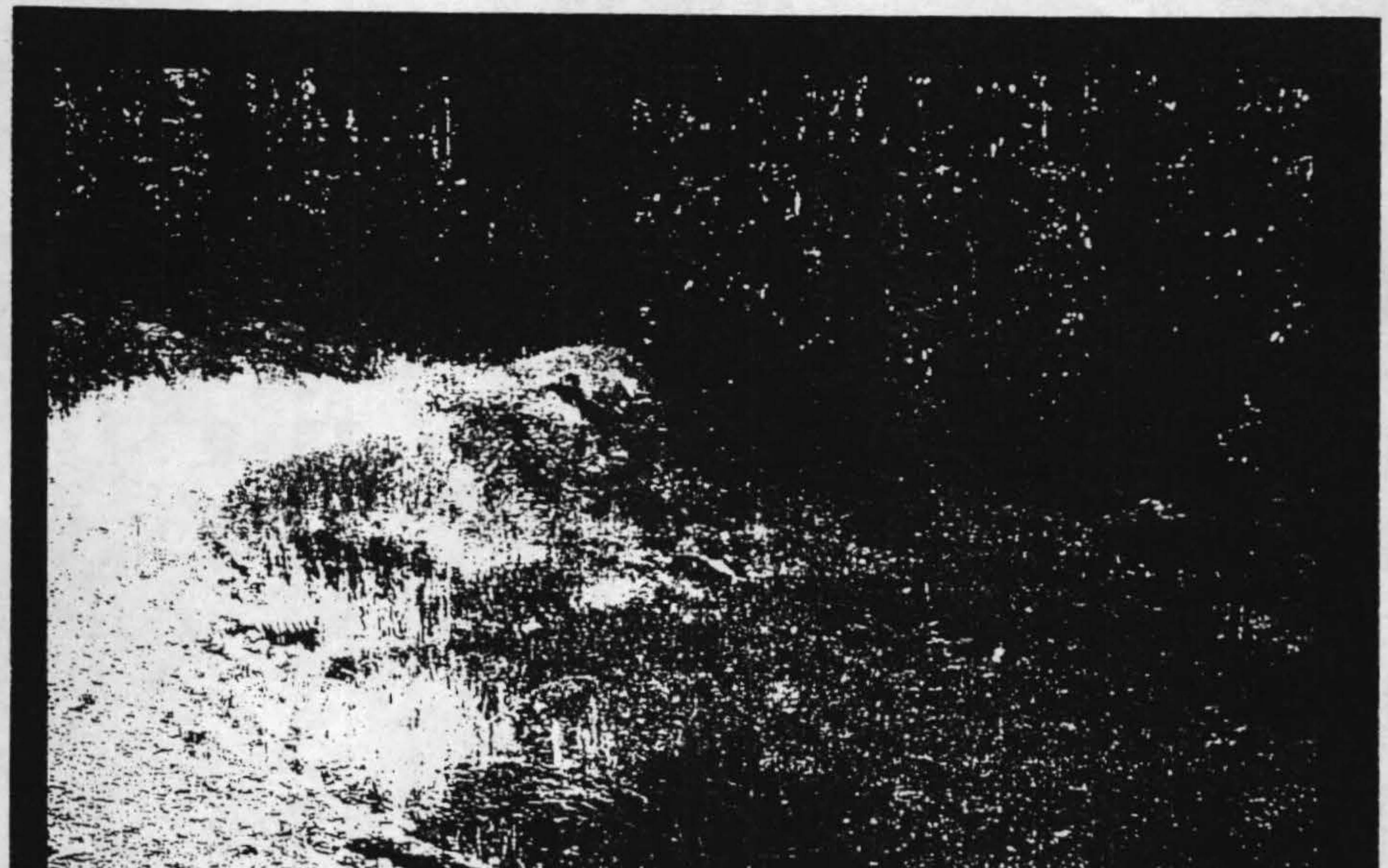
THE IMPACT OF FORESTRY ROADS ON PEATLANDS WITHIN THE TONGASS NATIONAL FOREST, SOUTHEAST ALASKA

Paul H. Glaser



August 26, 1999

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Hi Ken:

I finally finished the report for the peatland study we did last August. I know that it took too long, but I am pleased with the final product. In addition to the information on peat landforms and vegetation, I found that the water chemistry was also quite interesting. I also sent the rock samples out for thin-sections and X-ray diffraction analysis of their mineral contact. I am still amazed that we could not find more conspicuous evidence for road impacts on peatlands. The water chemistry is also surprising dilute given the close proximity to the ocean and high rates of precipitation.

Please feel free to make any comments on its contents. We can also reduce this report into an article for a magazine or a journal. If you could send an example of the desired format it should not take too long. The work was quite interesting and it will be fun to write a short article on our major findings.

I still think about our trip last summer. What an exceptional landscape! I would be very interested to learn if Bill Herzog has published the hydrological study from Wrangell Island. There are too many journals these days and it is hard to keep current with the literature.

I hope all is well,

Paul

Paul

The Impact of Forestry Roads on Peatlands within the Tongass National Forest, Southeast Alaska

Peatlands provide a striking contrast to the dense rainforests that typically blanket the landscape of Southeast Alaska. Locally known as "muskegs" peatlands are readily identified by their deep deposits of organic matter, permanently high water-table, and absence of forest cover. Many peatlands also contain networks of terraced pools and scattered clumps of stunted conifers that produce the appearance of a landscaped garden. The scenic appeal of these peatlands is further enhanced by their sweeping views of the surrounding forest and mountains. Unfortunately, there has been growing concerns that the integrity of these peatlands has been threatened by networks of roadway that were constructed throughout the Tongass National Forest. Roadways usually produce irreversible changes in there fragile ecosystems by locally altering the hydrology.

Hydrology plays a decisive role in controlling the development of peatlands both by maintaining the high water table necessary for peat to accumulate and also by transporting inorganic nutrients from external sources through the peat. Slight alterations to the hydrology can cause profound impacts on peatland ecosystems that produce striking vegetational changes or the physical degradation of the entire ecosystem. Peatlands are therefore widely recognized as sensitive indicators of the hydrogeologic setting and can be used to monitor environmental change.

The current study was undertaken to determine whether the network of forestry roads within the Tongass National Forest has had a noticeable and detrimental effect on peatlands. Three study areas were selected on Chichagof Island (Corner Bay), Kupreanof Island (Bohemia Mountain road), and Wrangell Island where the effects of road construction on peatlands should be most conspicuous. The most conspicuous indicators

for major road impacts on peatlands, should be unexpected changes in the landforms, water chemistry, and vegetation patterns.

Road Impacts on Peatlands

Human societies have impacted peatlands from the time that Neolithic farmers first constructed trackways of oak or wattle across the raised bogs of Europe. These elaborate structures were laid down during periods of rapid peat accumulation about 5,000 years ago during a period of cool and moist climatic conditions. The early roadways had minimal impact on the peatlands themselves and were eventually buried under fresh new layers of accumulating peat. In contrast, the construction of modern roadways is usually associated with major alterations to the local hydrology. These effects are amplified when roadways are oriented perpendicular to the slope and are associated with drainage ditches, culverts, or wide berms.

The most serious impacts are created by roads that obstruct the natural drainage across a peatland. Local impoundments on the upslope side of the road will raise the water table and favor significant changes in the vegetation as hydrophilous species invade and dominate these sites. Hydrologic barriers will also lower the water table on the downslope side of the road particularly if the water is diverted to the margins of the peatlands by drainage ditches. A lower water table favors the invasion and growth of woody plants on drier sites with trees and shrubs replacing the more hydrophilous sedges. Hydrological effects are intensified where drainage ditches are cut along the edges of the roadway and channel runoff off the peatland. The spoil banks for these ditches than serve as sites for the invasion of "exotic" non-peatland species, in addition to being ignition sources for wildfires.

Roadways also provide a local source of inorganic solutes that are leached from the roadbed materials and are then transported onto the peatland downslope. Plumes of nutrients may have a major impact on the vegetation of oligotrophic (nutrient poor) peatlands producing "flushes" dominated by more nutrient demanding species. The

berms and shoulders of some roadways also provide a migration pathway for weedy species that may invade altered areas of peatland adjacent to the road that have either dried out or been fertilized by nutrients leaching from the roadbed. These vegetation effects are most striking for the input of nitrogen (which produces a flush of vegetation growth and the invasion of grasses or cattails) or the addition of calcium carbonate to bogs (pH <4.2; Ca <2 mg/l) or poor fens (pH 4.2-5.5; Ca 2-6 mg/l).. The later effect favors the invasion and spread of poor-fen indicators, such as *Carex livida*.

Study Areas

Three study areas were selected on Chichagof, Kupreanof, and Wrangell Islands in Southeast Alaska to determine the different effects of forestry roads on peatlands. In each area, roadways intersect a wide array of peatlands from different physiographic settings. The roadways were constructed from different geologic material providing an additional standard of comparison. The peatlands ranged from raised bogs to sloping poor-fens on a variety of slopes. Nearly all of the peatlands, studied contained networks of oriented pools and scattered clumps of stunted conifers.

Nine sites were studied along the roads that arise from Corner Bay (Tenakee Inlet) on the west coast of Chichagof Island. Two of these sites are located on a gentle alluvial terrace at the base of steep ridges along the road to Hook Creek/Kadashan Management Area (FR#7500). The remaining 7 sites were selected along the Corner Creek Road (FR#7540) that follows a broad U-shaped glacial valley. Three peatlands were selected on the more gently sloping landscape of northeastern Kupreanof Island along the Bohemia Mountain road (FR#6030) from Kake. The remaining two sites on Wrangell Island were previously investigated in 1996. Other peatlands near the town of Wrangell were examined for impacts from construction of a golf course and forestry slash.

Results

Vegetation and Water Chemistry

The peatlands investigated were either raised bogs or poor fens. These 2 types of peatlands may be separated on the basis of their landforms, vegetation, and water chemistry. The raised bogs have a noticeably elevated central plain that contains a few large isodiametric pools. The central plain is dominated by lawns of *Scirpus cespitosus* with a few scattered clumps of stunted *Pinus contorta* trees on the hummocks and near pools. The lower hollows are dominated by *Sphagnum*, whereas the higher hummocks have dwarf shrubs *Empetrum nigrum, Ledum groenlandicum, Kalmia polifolia, Andromeda glaucophylla* and lichens. The pools contain *Nuphar polysepalum*. The surface waters on the bogs typically have a low pH (<4.2) and low concentrations of calcium (<2 mg/l) and other cations.

In contrast, the poor fens generally developed over sloping terrain and usually had networks of pools oriented perpendicular to the slope. The pools were typically terraced with steep banks on their downslope side. Systems of subsurface pipes were noticeable particularly where the roof of the pipe has collapsed and exposed the rush of flowing water below. In other situations, the tortuous path of the pipes were indicated by flushes of *Fauria crista-galli.*

The vegetation on the sloping fens was similar to that found on the raised bogs except that more species occur on the fens. The major assemblages are dominated by *Nuphar polysepalum* in the pools, *Rhynchospora alba*. *Cladopodiella fluitans Siphula ceratities*, in hollows (that function as drains for overland flow during heavy rainfall)*Scirpus cespitosus* and *Rhychospora alba* on the lawns, *Empetrum nigrum, Ledum groenlandicum, Kalmia polifolia, Andromeda glaucophylla* , *Juniperus communis* on the hummocks. The water chemistry on these fens is relatively dilute, but can still be distinguished from that on the raised bogs by the higher pH (>4.2) and higher concentration of calcium (generally greater than 2 mg/l). It is rather surprising that the

chloritic or illitic clays) or a meta-basalt (80% chloritized basalt with the ferromagnesium minerals converted to chlorite feldspars).

Forestry roads generally skirt the margins of peatlands or cross larger peat deposits perpendicular to the slope. The roadfill seems to have been deposited directly over the peat surface without prior excavation or extensive damage to areas beyond the immediate vicinity of the roadway. The roads tended to have shoulders and berms on steeper slopes with shallow trenches along the upslope shoulder to divert drainage. Culverts, however, were also constructed in low points and at the base of slopes to facilitate drainage under the roadway. In contrast, the shoulders and berms were less apparent in more gently sloping settings.

Road impacts on peatlands

Vegetation Indicators

Forestry roads seem to have caused only minor alterations to peatlands in Southeastern Alaska. The most important impact is the burial of peat by the roadbed itself and its associated shoulders and berms. However, no consistent obstruction to the natural drainage was apparent even for roadways that intersect peatlands perpendicular to the slope. The only potential hydrological alterations may be water tracks that to arise from culverts on the downslope margins of the roads. However, even this effect was only noticed on a few peatlands and only have reinforced the natural drainage pattern that existed prior to the time of road construction.

Significant vegetation impacts are largely restricted to the immediate vicinity of a roadway (shoulders and berm) or localized zones where discharge from a culvert creates a flush of *Carex livida* or *Phalaris arundinaceae*. The roadside shoulders and berms provide a better-drained substrate of bare mineral soil that was colonized (or planting) by non peatland plants. On Chichagof Island, for example reed canary grass (*Phalaris arundinacaea*) has been planted along many roadsides. These stands of grass usually do not persist, except for the rare case (site CC9805) where a flush of reed canary grass and

other species actually spread in a plume-like flush from the outlet of a culvert onto the peatland downslope. The mineral shoulders of these roadways are often colonized by ferns, upland vascular plants, and conifers. A strip of shore pines (*Pinus contorta*), for example has developed along the shoulders and berms of the road that crosses one of the Wrangell study sites (W9813). The robust growth of these trees is probably related to the better drainage produced by the slope on the downslope side of the road and also the exposed mineral soil. Other than blocking a fine scenic view, the impact of this pine stand on the landscape is probably minimal.

Road impacts were less apparent on the peatlands farther from the roadways. The peatland vegetation is usually intact with no apparent alteration in the species assemblages except for the direct proximity of the road. Even in locations were crushed marble had spilled from the roadbed onto the peat surface no alterations in the vegetation is apparent. A conspicuous exception to this generalization, however, are the flushes of the poor-fen indicator *Carex livida* that emanate in a plume-like stand downslope from culverts. *Carex livida* flushes were observed on peatlands from Kupreanof (K9810) and Wrangell (W9814) where culverts discharged onto sloping poor-fens. The other exception was the flush of *Phalaris arundinacaea* along the Corner Creek road at Corner Bay. In other locations, however, the plantings of *P. arundinacaea* were not invasive and seemed to be declining to the point of extinction along many road shoulders.

Chemical Indicators

The surface-water chemistry provides another important indicator for determining the impact of forestry roads on peatlands. If the mire waters are simple mixtures from 2 different sources (e.g. precipitation and groundwater) the proportions of their dissolved constituents will plot along a simple mixing line as long as no internal sources or sinks exist within the peat. However, if another source/sink for these dissolved constituents exist these data points will deviate from the general mixing line. Generally, samples that

contain ions from an additional source will fall above the mixing line, whereas samples that have lost ions through precipitation or biological uptake will fall below the line.

The surface waters from the study sites are generally dilute with Ca, Mg, and Na as the principle species of cations. Three different mixing lines are evident for these cations that are indicative of the contrasting bedrock geology of the 3 study sites. These mixing lines correspond to waters draining from A) granite/anorsothite (Wrangell Island), B) volcanics/basalt/limestone (Corner Bay, Chichagof Island), and C) marble/andesite (Kupreanof Island, and Corner Bay, Chichagof Island). Each of these rock types will generate groundwater or surface waters with different Mg/Ca or Na/Ca ratios because of inherent differences in their mineral composition and weathering rates.

Waters that dissolve marble, for example will generally have a higher Mg/Ca ratio than waters that dissolve the other types of minerals, such as the Ca, Na, or K bearing feldspars or the Mg and Fe bearing mafic minerals in granites and anorthosites. Marbles are recrystallized limestones or dolostones in which magnesium can be incorporated into the crystalline lattice if it is not transported away by fluids. If dolostones (Ca, Mg-carbonate) are recrystallized and the magnesium remains to form recrystallized carbonate, the Mg/Ca ratio can approach unity. In contrast, Mg/Ca ratios are much lower in waters that dissolve granites/anorsothites in which the magnesium bearing minerals such as biotite constitute a very small fraction of the rock. Granites and anorthosites also dissolve at least an order of magnitude slower than carbonate rocks, such as marble or limestone. Weathered basalts and granites and low-grade metamorphic rocks, such as phyllites will generally dissolve at the slowest rates because secondary minerals coat their surface and create barriers to chemical diffusion. Waters that dissolve andesite volcanic rock will generally have higher Na/Ca and Mg/Ca ratios than those of granites or anorthosites.

Water samples from Wrangell Island generally had the lowest Mg/Ca ratios, which are typical for waters that drain from granitic bedrock or roadfill. The low Mg/Ca ratios

probably indicates the dissolution of feldspars in granite. Notice that the highest Ca value (sample 12) is associated with waters that discharged from a culvert into a *Carex livida* flush. Most of the samples from Corner Bay, Chichagof Island had higher Mg/Ca ratios because the volcanic basalts and limestones add more magnesium to the water than the feldspars in granite. The highest Mg/Ca ratios, in contrast are found in the samples from Kupreanof Island and some of the Corner Bay sites. This trend is expected for Mg-rich pyroxene minerals in dissolving marble or andesite.

Very similar trends occur with respect to the Na/Ca ratios. The granite mixing-line (A) shows essentially constant values for sodium as calcium concentrations increase. This relationship is consistent with the weathering of granitic feldspars that lose calcium more rapidly than sodium. In contrast, the mixing line for dissolving basalts and limestone (B) corresponds to the expected 2:1 ratio of calcium to magnesium. The marble/andesite mixing-line, however, spans a range from very low sodium values (sample 9 on Kupreanof Island) indicative of the marble dissolution, to the relatively high sodium values that indicate a greater proportion of dissolving sodic-rich andesites.

Despite these different source materials, the surface water samples are surprisingly dilute with total dissolved solids (TDS) less than 30 mg/l and often less than 15 mg/l. In contrast, the TDS of groundwater in mineral soils and bedrock is usually greater than 200 mg/l in most hydrogeologic settings. Therefore any groundwater discharging onto these peatlands must be diluted by almost 10 times before it collects in the mire pools. Alternatively, if the base cations are derived from road materials the rates of dissolution are either very slow or the more concentrated solutions are significantly diluted to very low concentrations. The observed concentrations, for example are only 2-3 times greater than those expected from precipitation. This effect may minimize the impact of leachates from roadbeds onto peatlands within the three study sites and make it difficult to spot contamination sources by the bivariate plots described above.

Conclusions

Although forestry roads often intersect various types of peatlands, the impact of these roads seem to be minimal except for a few localized flushes that arise from the downslope outlet of culverts. The apparent absence of more conspicuous impacts may be attributed to 1) high regional precipitation, 2) porous nature of the roadbed material, and 3) roadbed construction.

One of the striking features of the surface water chemistry from both bogs and fens in Southeast Alaska is the surprisingly low concentration of inorganic solutes. Precipitation from oceanic regions typically has high concentrations of Mg and Na, which is reflected in the surface water chemistry of both bogs and fens. Water samples from peatlands throughout Southeast Alaska, however have surprisingly low concentrations of these solutes given their maritime setting. Even in comparison to other peatlands in boreal North America the surface waters from the Tongass peatlands have strikingly dilute waters. However, the average annual precipitation in Southeast Alaska can be more than double or triple of that found in other northern maritime regions with extensive peatlands. These high levels of precipitation are probably responsible for diluting the surface waters and flushing the leachate from roadways.

Despite the high regional precipitation no evidence was detected for major impoundments, diversions, or drawdowns of surface water. The roadbed material seemed too porous to substantially block flow draining across the peatland upslope from a roadway, or the high precipitation prevents the peatland downslope from the road from drying out. The absence of any hydrological impacts is also indicated by the absence of any change in the mire pools either upslope or downslope from roadways. The only potential hydrological impact was produced by some of the culverts, which may have channeled surface runoff with higher concentrations of solutes onto the peatland from the downslope margin of the road. Even here, the extent of the vegetation flush that arises from certain culverts 1) was limited in extent at Wrangell, 2) may have predated the

roadbed at Kupreanof, but probably 3) was responsible for the influx of mineral soil and fertilizer on the Corner Bay site. Otherwise, the roadside fertilizer would have been quickly flushed from the peat by the high seasonal precipitation and runoff. This later effect is most noticeable around the new golf course on Wrangell Island where intact swamp forests border the greens of new fairways.

PLATE CAPTIONS

Plate 1 Corner Bay, Chichagof Island

a) Corner Bay (near CC9807) Invasion of *Phalaris arundinaceae* (brilliant light-green foliage) onto a sloping fen downslope from a culvert. Notice the limited extent of the *Phalaris* flush, which is invading a fen lawn dominated by *Scirpus cespitosus* .

b) Corner Bay (near CC9807). Restriction of planted *Phalaris arundinaceae* (brilliant light-green foliage) to the shoulder of a roadway. The nonforested area in the background is a fen lawn dominated by *Scirpus cespitosus.*

c) Corner Bay (site CC 9805). Extensive flush of *Phalaris arundinaceae* (brilliant light-green foliage) and other "exotics" that have invaded a steeply sloping peatland downslope from a culvert. The culvert is probably a point source for mineral sediment as well as fertilizer that is/was transported onto the peatland downslope within storm runoff.

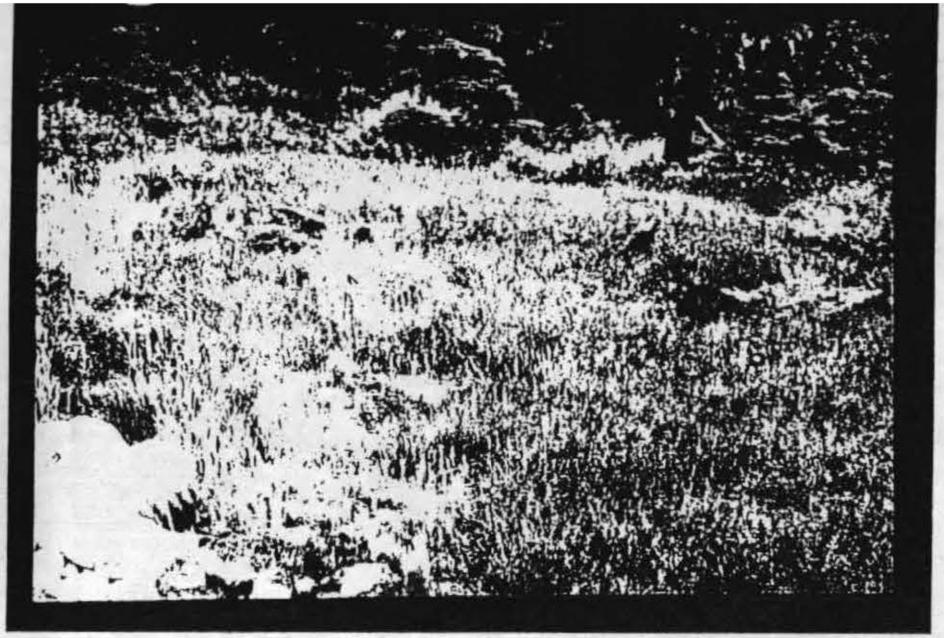
d) Corner Bay (near site CC9807). Swards of *Phalaris arundinaceae* (brilliant light-green foliage) line the road margins adjacent to a nonforested fen lawn. Notice the restricted growth and discontinuous clumps of *Phalaris* that indicate the decline of these swards.

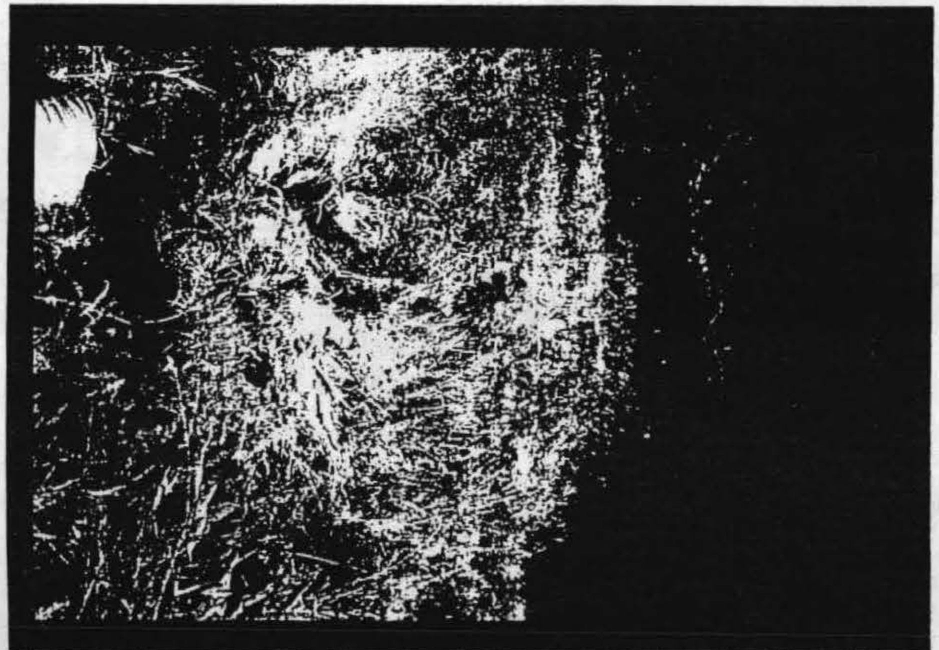
Plate 2, Corner Bay, Chichagof Island and Kupreanof Island

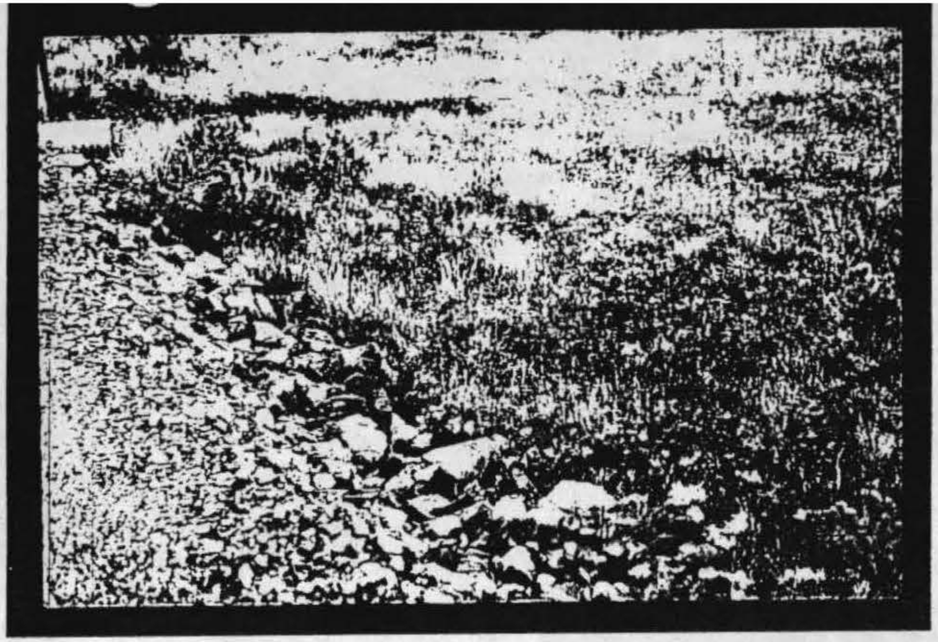
a) Kupreanof Island (site K9810). Intact poor-fen vegetation growing in contact with road materials. The peatland species visible include *Scirpus cespitosus, Fauria crista-galli,* and *Pinus contorta.*

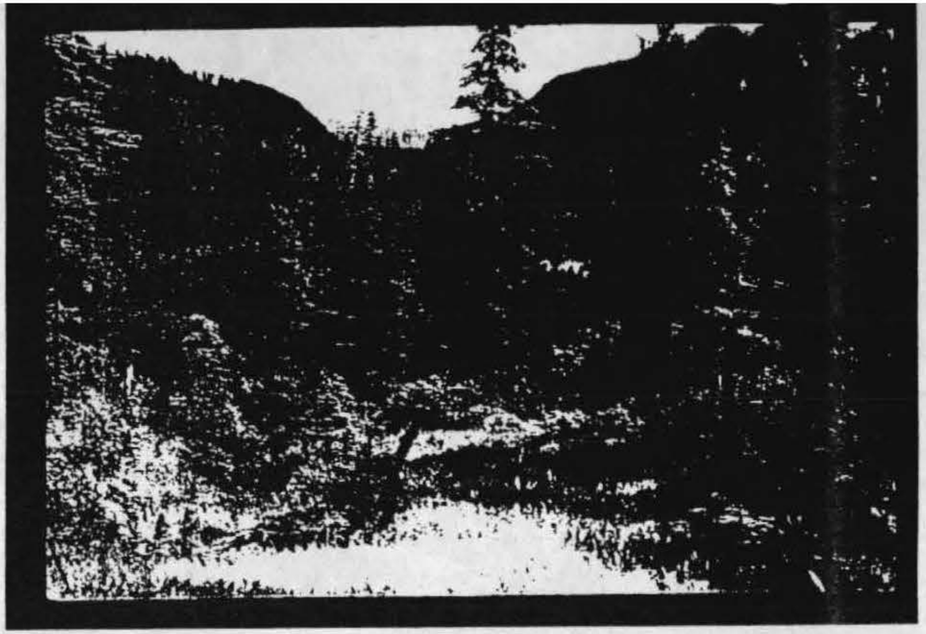
b) Corner Bay (site CC9805). Extensive flush of *Phalaris arundinaceae* (brilliant light-green foliage) arising downslope from the mouth of a culvert.

c) Kupreanof island (site K9810). A flush of *Carex livida* (blue-gray foliage) arising downslope from a culvert. Notice the contrast between the stand of *C. livida* and the darker foliage of the *Scirpus cespitosus* dominated poor-fen in the background.









d) Kupreanof island (site K9810). Roadside with nearly intact poor-fen vegetation. The nonforested lawn of *Scirpus cespitosus* contains local clumps of stunted *Pinus contorta*.

Plate 3, Kupreanof Island

a) Fen pool (site K9810) downslope from a culvert with a population of *Sparganium angustifolium.* The edges of the pool are lined with *Carex livida* (gray-green shoots), *Scirpus cespitosus* (yellow-brown foliage), *Fauria crista-galli* ,and *Pinus contorta.*

b) Flush of *Carex livida* (gray-green zone in the foreground) in a small water track arising downslope from a culvert (site K9810). Notice the sharp boundary between the *Carex livida* flush and the *Scirpus cespitosus* lawn (yellow-to-brownish green foliage) in the background with scattered clumps of *Pinus contorta.*

c) Oblique aerial photograph of sloping peatlands with networks of pools along the Bohemia Mountain road (FR 6030) on Kupreanof Island. There are no visible changes in peatland vegetation and landforms associated with the roadway.

d) Another view of the *Carex livida* flush from Plate 3b above. Notice the narrow stand of *Scirpus cespitosus* (yellow-green foliage) along the edge of the roadway and the oriented pools in the water track itself.

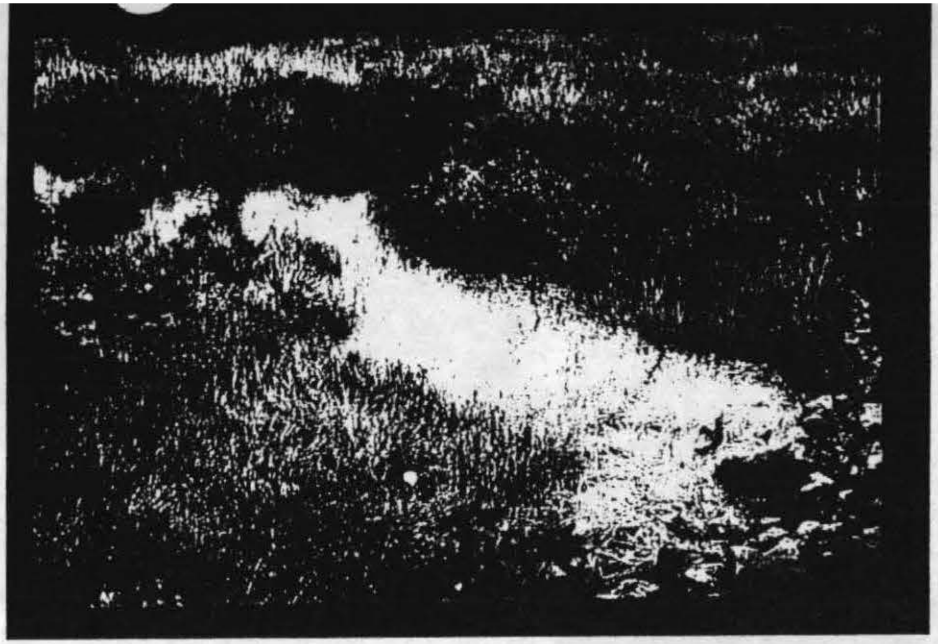
Plate 4. Kupreanof Island

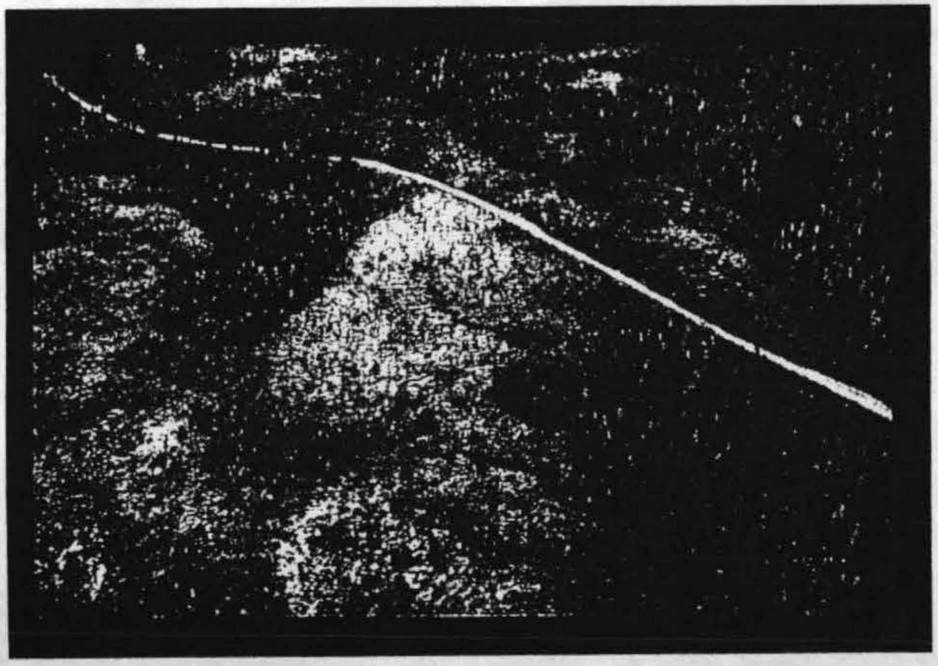
a-d) Oblique aerial photographs of sloping peatlands intersected by the Bohemia Mountain road (FR#6030). No visible changes are apparent in either the vegetation patterns or the landforms that are associated with the roadway.

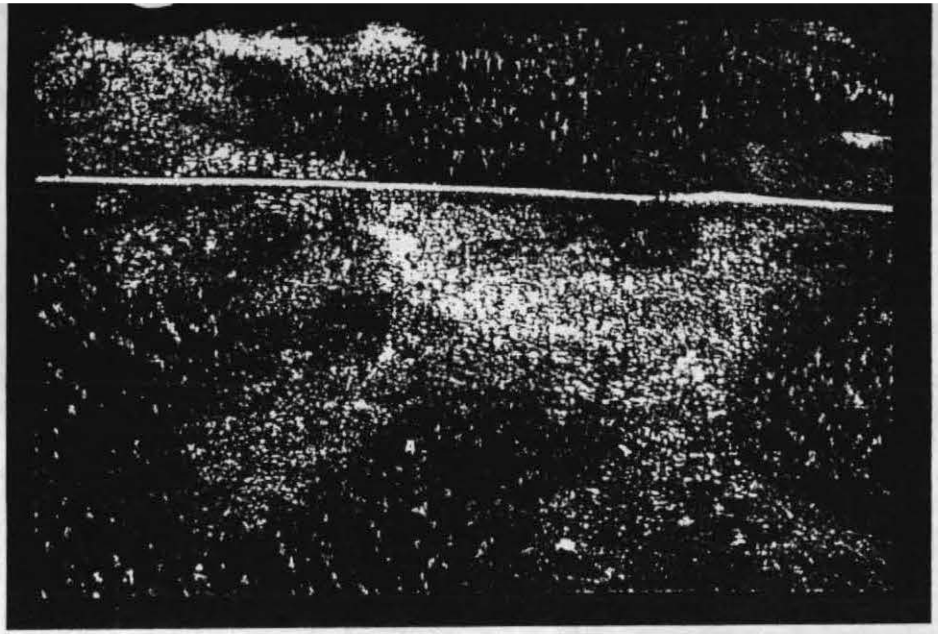
Plate 5. Kupreanof Island and Wrangell Island.

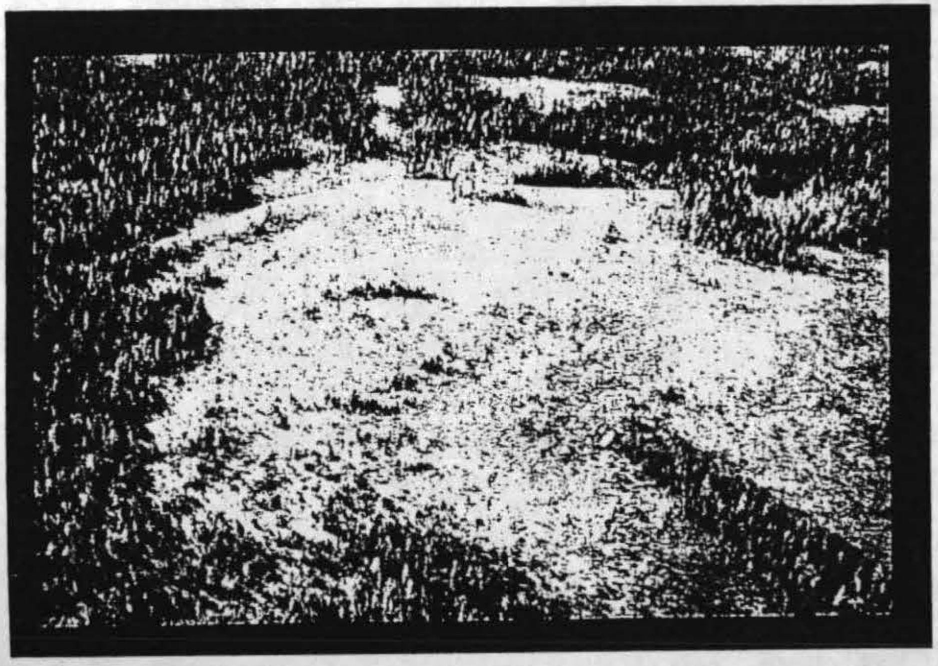
a) Thin swards of exotic grass (light-green bands) along roadway adjacent to sloping peatland (site WR9813) on Wrangell Island.

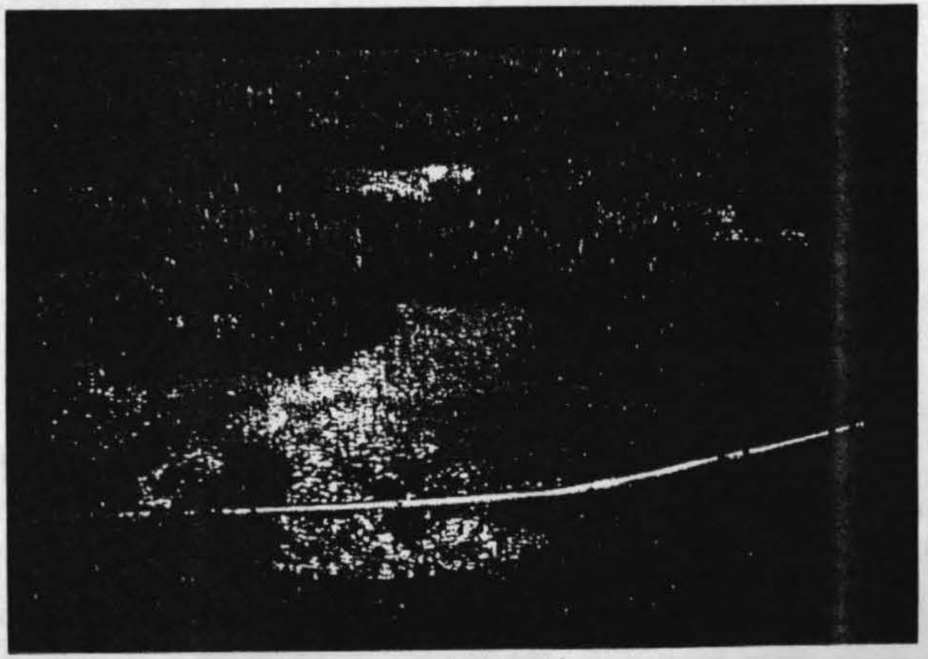
b) Oblique aerial photograph of a sloping peatland intersected by the Bohemia Mountain road (FR#6030), Kupreanof Island. Water flows from the upper to lower portion of the picture perpendicular to the road. Notice the absence of apparent changes in the

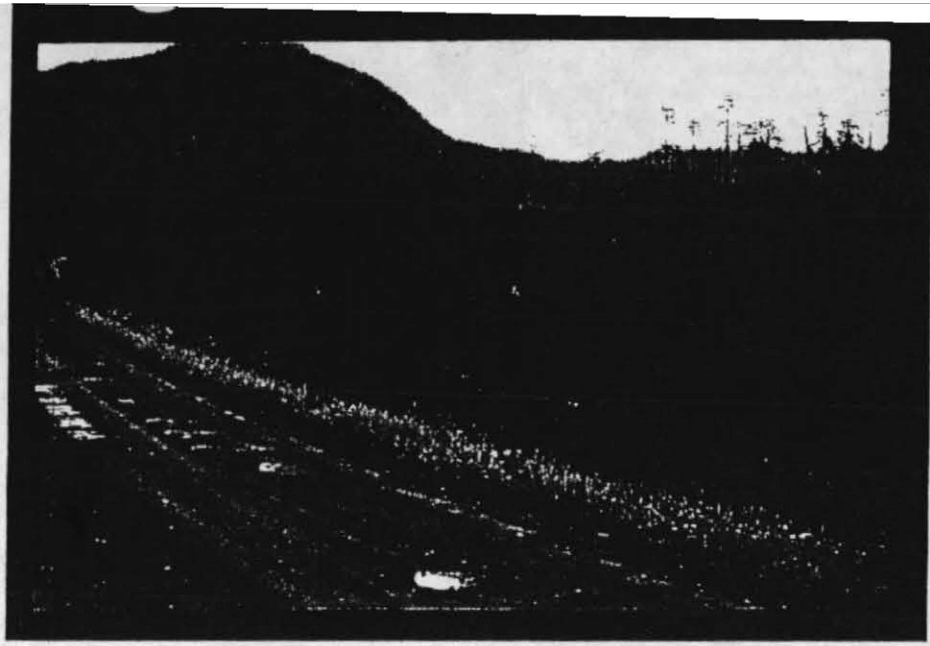


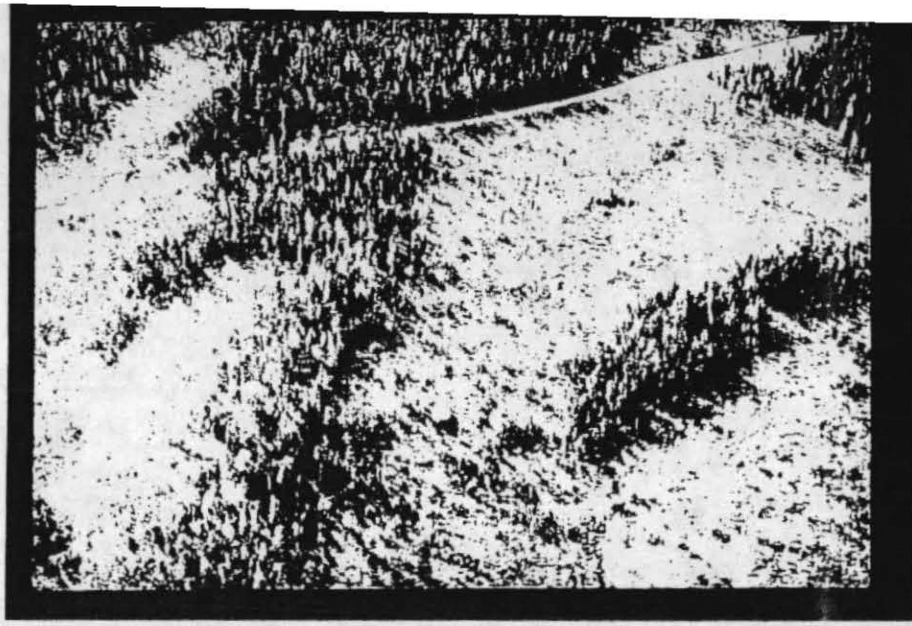


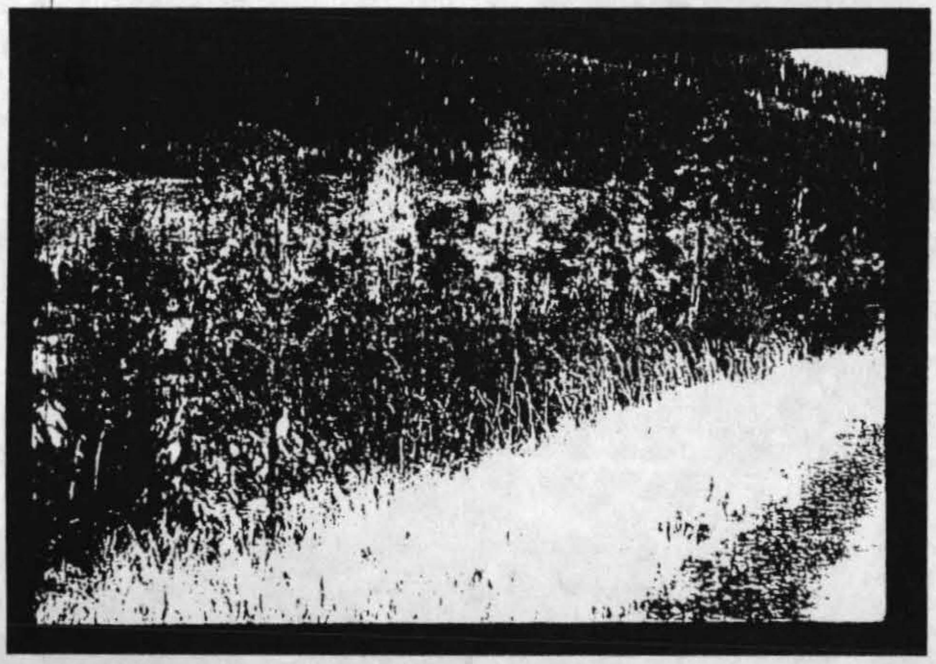



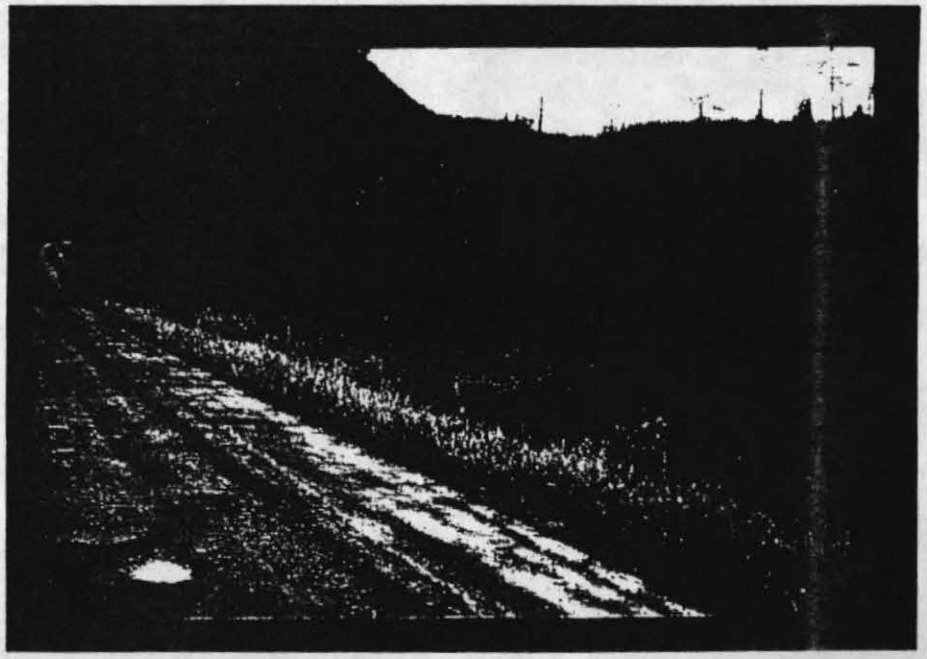












pool hydrology either upslope or downslope from the road toward the upper right hand side of the photograph.

c) Thick stand of exotic grasses (light-green foliage) along the McCormick Creek Road adjacent to a sloping peatland (site WR9813). The stand of exotic vegetation growing along the berm of the road includes *Phragmites communis.* (tall stalks). Also note the robust growth of the shore pines (*Pinus contorta*) growing along the berm of the roadway. Contrast the vegetation on this downslope margin of the road to that on the upslope side of the roadway (Plate 5a and 5d). The more robust growth of the roadside vegetation is related to the more extensive deposit of fill material.

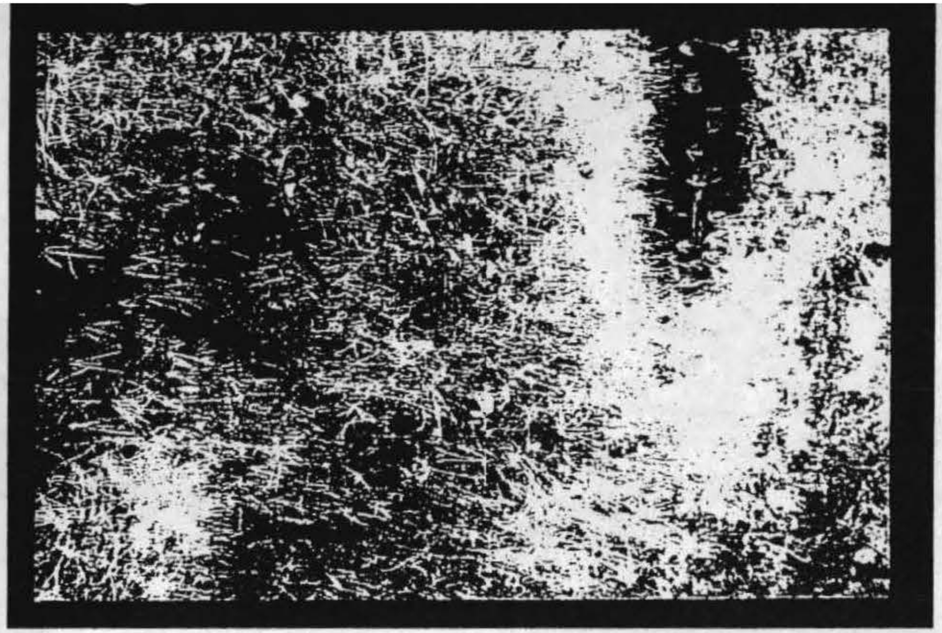
a) Thin swards of exotic grass (light-green foliage) along McCormick Creek Road adjacent to a sloping peatland (site WR9813) on Wrangell Island. The peatland upslope is marked by a *Scirpus cespitosus* lawn with scattered clumps of *Pinus contorta*. The taller trees occur on mineral soil.

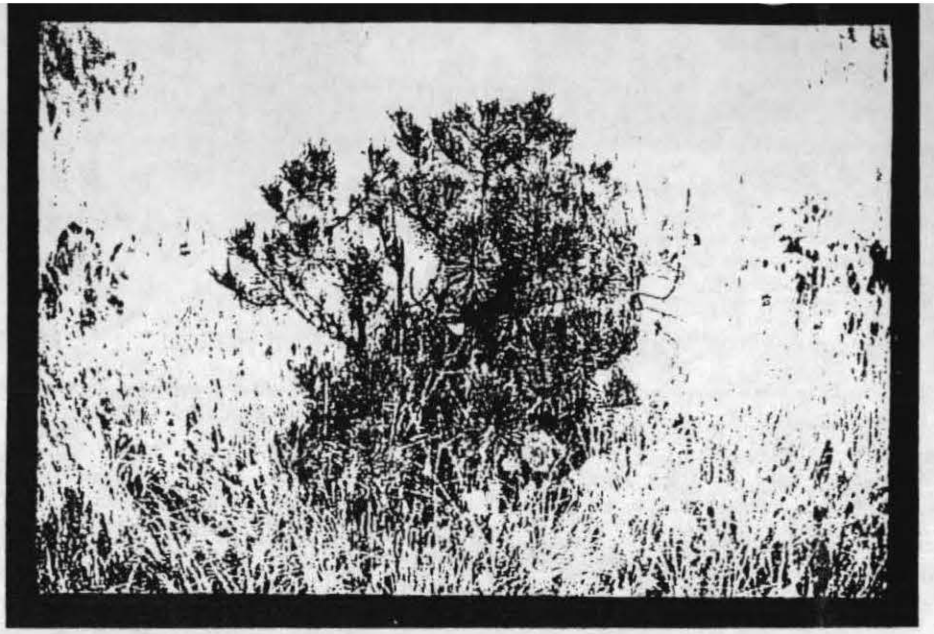
Plate 6: Wrangell Island.

a) Steeply terraced pools on a sloping peatland (site WR9813) on Wrangell Island. The upper pool contains *Menyanthes trifoliata* and a fringe of *Carex livida* (gray-green foliage). The steep bank of the terrace is mostly composed of *Scirpus cespitosus*. Note the opening of a pipe at the base of the terrace (small arrow). The orientation of the photo is marked by the larger arrow.

b) Stunted *Pinus contorta* with some signs of chlorosis (yellowing) of foliage on a sloping peatland (site WR9813).

c) Thick stand of exotic grasses (light-green foliage) along the McCormick Creek Road adjacent to a sloping peatland (site WR9813). .





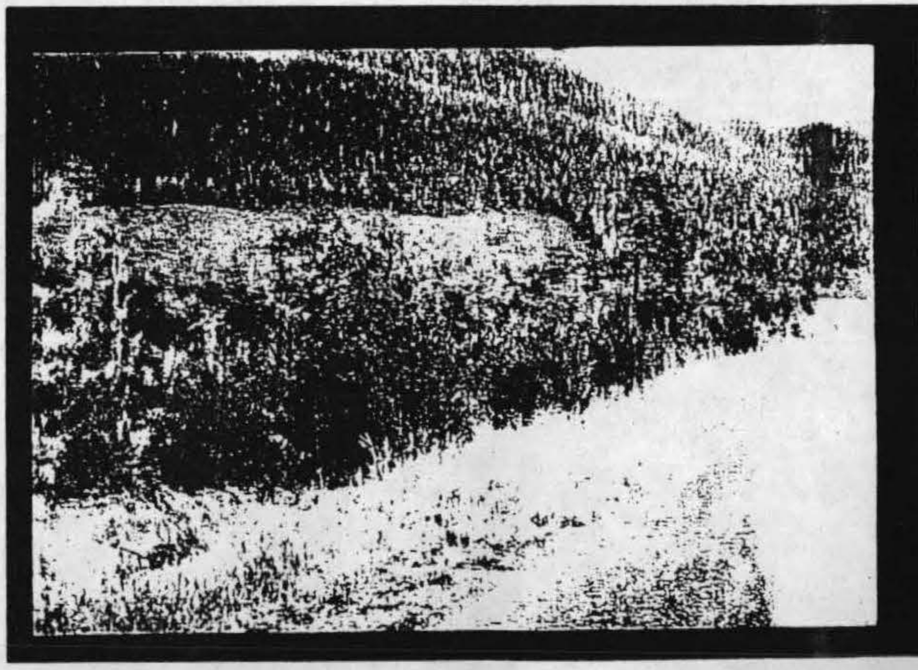


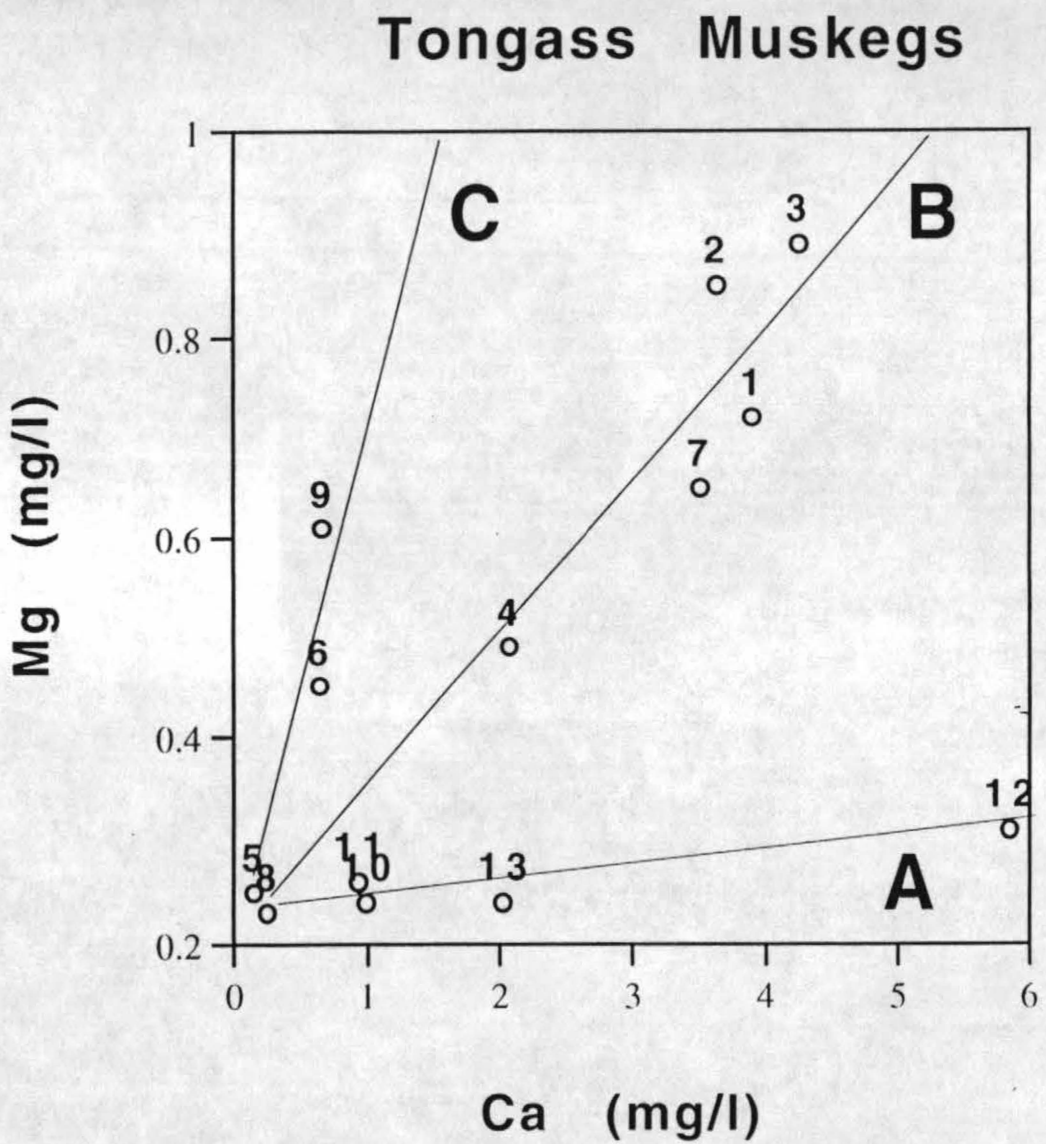
FIGURE CAPTIONS

Figure 1: Surface water chemistry for Tongass peatlands

Three different mixing lines are evident in this plot of calcium vs. magnesium from surface water samples from the 3 study sites. The mixing lines all have different Ca:Mg ratios indicative of dissolution from different rock types. These types are **A**: granite, **B**: basalts/limestone, and **C**: marble/andesite. The numbers correspond to the study sites listed in Table 1.

Figure 2: Surface water chemistry for Tongass peatlands

The same 3 mixing lines are also evident in this plot of calcium vs. sodium.


Tongass Muskegs
Mg (mg/l)
Ca (mg/l)
C
B
A
1
0.8
0.6
0.4
0.2
0
1
2
3
4
5
6
1
2
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10
11
12
13

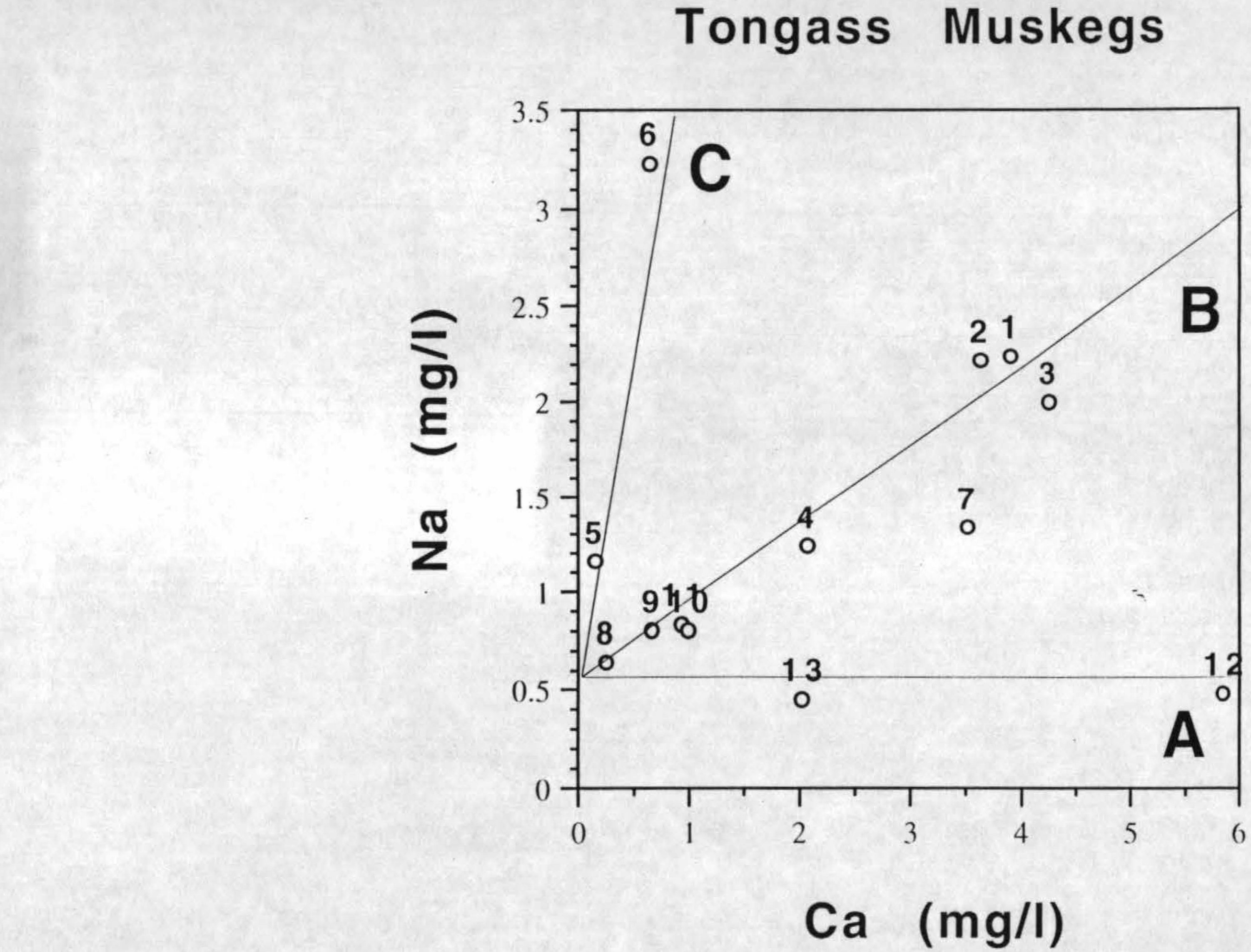
Tongass Muskegs
Na (mg/l)
Ca (mg/l)
3.5
3
2.5
2
1.5
1
0.5
0
0
1
2
3
4
5
6
C
B
A
6
2
1
3
7
4
5
9
11
10
8
13
12

TABLE CAPTIONS

Table 1: Study sites in the Tongass National Forest

Table 2: Vegetation Table for Tongass peatlands

Table 3: Water chemistry for Tongass peatlands

Table 1

Tongass National Forest Study Sites

Site ID	Island	Site Name	Location	Mire Type
HC9801	Chichagof	Corner Bay/Kadashan-Hook Creek	T48SR63ESec10	poor fen
HC9802	Chichagof	Corner Bay/Kadashan-Hook Creek	T48SR63ESec10	poor fen
CC9801	Chichagof	Corner Bay/Corner Creek	T48SR64ESEC7	raised bog
CC9802	Chichagof	Corner Bay/Corner Creek	T48SR64ESEC34	raised bog
CC9803	Chichagof	Corner Bay/Corner Creek	T48SR64ESEC34	poor fen
CC9804	Chichagof	Corner Bay/Corner Creek	T48SR64ESEC21	marsh
CC9805	Chichagof	Corner Bay/Corner Creek	T48SR64ESEC1	poor fen (ridge)
CC9806	Chichagof	Corner Bay/Corner Creek	T48SR64E	poor fen (m)
CC9807	Chichagof	Corner Bay/Corner Creek	T48SR64E	raised bog (vs)
K9801	Krupeanof	Bohemia Mtn road 6030	T57R75ESEC18	poor fen
K9802	Krupeanof	Bohemia Mtn road 6030	T57R75ESEC18	poor fen
K9803	Krupeanof	Bohemia Mtn road 6030	T57R75ESEC18	raised bog
W9801	Wrangell	McCormick Creek Road	T64SR84ESEC24	poor fen
W9802	Wrangell	Road 50024	T64SR84ESEC24	poor fen

Table 2

Peatland Type	CB-2 SF	CB-3 FB	CB-4 FB	CB-5 SF	CB-6 SF	CB-8 FB	CB-9 FB	K-1 SF	K-2 SF	K-3 FB
Vaccinium oxyccocos	1		1	1						
Scirpus cespitosus	3	3	1	1	3		3	3	3	3
Kalmia polifolia	1	1	1	1	1	1	1		1	1
Empetrum nigrum	1	2	2		2	1	2	2	2	2
Ledum groenlandicum	1	2	2		2	2	2	2	2	2
Carex pauciflora	1	2	2	1	2	2		2		2
Vaccinium uliginosum		2	2	2		2	2	2	1	2
Cornus suecica	1	+	+	1	1		1	+	1	
Gentiana douglasiana				1	1	1	1	+	+	
Pinus contorta		+	+			+	+	1	2	+
Fauria crista-galli	1			1	1	3		1	1	
Carex pluriflora							1	1	1	1
Rubus chamaemorus		1	1	+			1	1	1	1
Sanguisorba menziessii								+	+	+
Rhynchospora alba	1							2	2	
Eriophorum angustifolium		+	+				+	+	+	
Tsuga heterophylla	1	+				2	1	+		
Lysichiton americanum	1					1	+	+		
Menyanthes trifoliata	1			1				1		
Coptis trifolia			+	+			+			
Nuphar polysepalum		1	1							
Carex livida	2							2		
Andromeda polifolia					1			1		
Drosera anglica	1							+		+
Tofieldia glutinosa	1	+						+		
Drosera rotundifolia								+		
Juniperus communis									+	
Carex sitchensis			+							
Geum calthifolium										
Deschampsia caespitosa				1						
Scheuchzeria palustris	1									
Chamaecyparis nootkatensis								+		
Coptis aspleniifolia										
Blechnum spicant				+						
Sparganium hyperboreum								+		
Carex phyllomanica		1								
Smilacina trifolia	1									
Carex magellanica					1					
Phalaris arundinceae				2						
Thuja plicata					+					
Carex phyllomanica								+		
Siphula ceratites										2

Site I.D.	Site	Date	pH	Cond.	Ca	Mg	K	P	Mn	Al	Fe	Na	Zn	Cu	B	Pb	Ni	Cr	Cd
1 (8-24-98-1)	Corner Bay-HC1a	8/24/98	6.2	46.5	3.90	0.72	<0.71	0.04	<0.003	0.32	0.22	2.24	0.01	<0.03	0.02	<0.08	<0.02	<0.01	<0.01
2 (8-24-98-1)	Corner Bay-HC1a	8/24/98	6.2	46.5	3.63	0.85	<0.71	<0.04	0.12	0.43	0.72	2.22	0.01	<0.03	0.02	<0.08	<0.02	<0.01	<0.01
3 (8-24-98-2)	Corner Bay-HC1b	8/24/98	6.4	35.4	4.25	0.89	<0.71	<0.04	0.65	0.31	0.73	2.00	0.01	<0.03	0.02	<0.08	<0.02	<0.01	<0.01
4 (8-24-98-4)	Corner Bay-HC2	8/24/98	6.3	42.5	2.07	0.49	<0.71	<0.04	0.03	<0.18	0.25	1.24	<0.01	<0.03	0.02	<0.08	<0.02	<0.01	<0.01
5 (8-25-98-2)	Corner Bay-CC1	8/25/98	4.3	161.5	0.64	0.45	<0.71	<0.04	0.01	<0.18	0.06	3.23	0.02	0.03	0.02	<0.08	<0.02	<0.01	<0.01
6 (8-25-98-3)	Corner Bay-CC2	8/25/98	4.3	164.3	0.15	0.25	<0.71	<0.04	0.00	<0.18	0.04	1.16	0.01	<0.03	0.02	<0.08	<0.02	<0.01	<0.01
7 (8-25-98-3)	Corner Bay-CC3	8/25/98	6.3	40.9	3.51	0.65	0.98	<0.04	0.02	0.25	0.42	1.34	0.05	<0.03	0.02	<0.08	<0.02	<0.01	<0.01
8 (8-25-98-4)	Corner Bay-CC4	8/25/98	4.6	145.9	0.25	0.23	<0.71	<0.04	0.01	<0.18	0.11	0.64	0.01	<0.03	0.02	<0.08	<0.02	<0.01	<0.01
9 (8-26-98-1)	Kake	8/26/98	4.2	167.2	0.66	0.61	<0.71	<0.04	0.01	<0.18	0.10	0.80	0.02	<0.03	0.02	<0.08	<0.02	<0.01	<0.01
10 (8-27-98-1)	Wrangell-A	8/27/98	5.3	100.9	0.99	0.24	<0.71	0.07	0.00	0.30	0.13	0.80	0.01	<0.03	0.02	<0.08	<0.02	<0.01	<0.01
11 (8-27-98-2)	Wrangell-B	8/27/98	5.4	97.6	0.93	0.26	0.71	0.04	<0.003	0.30	0.11	0.83	0.01	<0.03	0.02	<0.08	<0.02	<0.01	<0.01
12 (8-27-98-3)	Wrangell-C	8/27/98	6.3	45.4	5.85	0.31	<0.71	<0.04	<0.003	0.22	0.06	0.48	0.01	<0.03	0.02	<0.08	<0.02	<0.01	<0.01
13 (8-27-98-4)	Wrangell-D	8/27/98	5.7	80.1	2.02	0.24	<0.71	<0.04	<0.003	0.22	0.06	0.45	0.01	<0.03	0.02	<0.08	<0.02	<0.01	<0.01